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NOTES ON GEOGRAPHIC DISTRIBUTION

New record of *Sphaenorhyncus prasinus* Bokermann, 1973 (Anura, Hylidae) from northeastern Brazil

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Abstract. The distribution of *Sphaenorhynchus prasinus* Bokermann, 1973 in Brazil extends from eastern Bahia to eastern and central Minas Gerais, northern Espírito Santo, with isolated records in Alagoas and Pernambuco. Here, we present a new record of the occurrence of *S. prasinus* and the potential distribution of the species throughout the Brazilian Atlantic Forest. Our record increases the distribution of the species by 944 km from the type locality in the municipality of Ilhéus, state of Bahia and by 80 km from the northernmost record in Igarassu, Pernambuco.

Key words. Amphibia, Bokermann's Lime Treefrog, Brazilian Atlantic Forest, distribution extension, Pernambuco Endemism Center

Vieira WLV, Vieira KS, Delfim FR, França FGR, Alves RRN, Montenegro PFG, Pereira Filho GA (2024) New record of *Sphaenorhyncus prasinus* Bokermann, 1973 (Anura, Hylidae) from northeastern Brazil. Check List 20 (6): 1320–1325. https://doi.org/10.15560/20.6.1320

INTRODUCTION

The genus *Sphaenorhynchus* Tschudi, 1838 constitutes a monophyletic clade (Pyron and Wiens 2011; Duellman et al. 2016; Faivovich et al. 2018; Araujo-Vieira et al. 2019; Pereira et al. 2022) comprising 15 Neotropical species of small to medium-sized green tree frogs distributed in the Amazon and Orinoco basins of South America, Trinidad and Tobago, Guianas, and eastern Brazil (Duellman et al. 2016; Araujo-Vieira et al. 2019; 2020; Frost 2024). Three species—*S. carneus* (Cope, 1868), *S. dorisae* (Goin, 1957), and *S. lacteus* (Daudin, 1800)—are distributed west of South America in Peru, Ecuador, Colombia, Guyana, and the central Amazon in Brazil (Pereira et al. 2022; Frost 2024). *Sphaenorhynchus lacteus* also occurs in northeastern Brazil with records in the states of Maranhão and Piauí (Caramaschi et al. 2009; Benício et al. 2011), as well as in Trinidad and Tobago (named as *Hyla orophila* by Kenny 1969). *Sphaenorhynchus platycephalus* (Werner, 1894) is known from Serra do Mar and Serra da Mantiqueira in the states of Rio de Janeiro, São Paulo, and Minas Gerais in southeastern Brazil, at elevations above 1,000 m (Araujo-Vieira et al. 2018; Frost 2024). The other species, *S. botocudo* Caramaschi, Almeida & Gasparini, 2009; *S. bromelicola* Bokermann, 1966; *S. cammaeus* Roberto, Araujo-Vieira, Carvalho-e-Silva, & Ávila, 2017; *S. canga* Araujo-Vieira, Lacerda, Pezzuti, Leite, Assis & Cruz, 2015; *S. caramaschii* Toledo, Garcia, Lingnau & Haddad, 2007; *S. mirim* Caramaschi, Almeida & Gasparini, 2009; *S. palustris* Bokermann, 1966; *S. pauloalvini* Bokermann, 1973; *S. planicola* (Lutz & Lutz, 1938); *S. prasinus* Bokermann, 1973, and *S. surdus* (Cochran, 1953), are distributed throughout the Atlantic Forest domain in Brazil and have been recorded from the northern portion of the state of Rio Grande do Sul to the state of Pernambuco (Frost 2024).

Sphaenorhynchus prasinus Bokermann, 1973 is characterized by its medium size (snout–vent length (SVL) 28–31 mm), truncated snout in dorsal and lateral views, dark canthal line which extends from the tip of the snout to the anterior corner of the eye, indistinct tympanum, absence of a dorsolateral white line from the posterior corner of the eye to the sacral region, well-developed and smooth dermal fold on the ventrolateral surface of the forearms and tarsi, dermal fold on the elbow and round calcar appendage, and presence of a white dermal fold with rounded lateral margins in the subcloacal region (Bokermann 1973). The distribution of *S. prasinus* in Brazil extends from eastern Bahia to eastern and central Minas Gerais,

OPEN ACCESS

Academic editor: Natan Medeiros Maciel
Received: 2 April 2024
Accepted: 15 November 2024
Published: 26 November 2024

and northern Espírito Santo, and there are isolated records in Alagoas and Pernambuco (Araujo-Vieira et al. 2016; Pereira et al., 2022; Frost 2024). In this context, we present a new record of the occurrence of *S. prasinus* and the potential distribution of the species throughout the Brazilian Atlantic Forest, especially in the Pernambuco Endemism Center, the most threatened sector of the Brazilian Atlantic Forest.

METHODS

Field research was carried out as part of the herpetofaunistic survey research project in a remnant of Atlantic Forest (Açude de Reis Forest) with 1495 ha belonging to Companhia Usina São João. This remnant forest is located in the rural area of the municipality of Santa Rita, Paraíba state, northeastern Brazil. Specimens of *S. prasinus* were collected through active time-constrained searches on 21.VIII.2023 in an area of a Semideciduous Seasonal Forest at 16–17 m in altitude. This area has lentic water bodies, including an artificial reservoir and temporary pools, and lotic water bodies consisting of small streams, and the remnant forest is surrounded by sugarcane monoculture. The collected specimens were anesthetized and euthanized with a subcutaneous injection of 2% lidocaine following to the guidelines on the Practice of Euthanasia of the Conselho Nacional de Controle de Experimentação Animal – Concea and Conselho Nacional de Biologia – CFBio Ordinance no. 148/2012. Afterwards, specimens were fixed in 10% formaldehyde and stored in 70% ethanol, according to Heyer et al. (1994). but before fixation, we collected muscle and liver tissue samples for storage in 99.6% ethanol. The collected specimens are housed in the Herpetological Collection of the Universidade Federal da Paraíba (CHUFPB). Collection permissions were granted by the Instituto Chico Mendes de Conservação e Biodiversidade (SISBio no. 78910-1) and also by the Animal Ethics Committee of the Universidade Federal da Paraíba (CEUA no. 7355310322).

A review of the geographic distribution of *S. prasinus* was carried out based on information available at the Global Biodiversity Information Facility (GBIF 2023) and in the literature (Feio et al. 1999; Feio and Caramaschi 2002; Juncá 2006; Toledo et al. 2007; Caramaschi et al. 2009; Santos and Moura 2009; Silva et al. 2013; Araujo-Vieira et al. 2015; 2016; Dubeux et al. 2020; Pereira et al. 2022). Based on this information, showing the occurrence of *S. prasinus* (containing 28 records) was produced using QGIS v. 3.32.0. Furthermore, the potential geographic distribution of the species was then carried out using the maximum-entropy method (MaxEnt v. 3.4.4), using only presence records in the model production (Phillip et al. 2006). A set of 19 bioclimatic variables (annual averages 1970–2000) served as input data: Bioclimatic Variations used to Model Production: BIO1 = Annual Mean Temperature; BIO2 = Mean Diurnal Range (Mean of monthly (max. temp–min. temp); BIO3 = Isothermality (BIO2/BIO7) (×100); BIO4 = Temperature Seasonality (standard deviation ×100); BIO5 = Max. Temperature of Warmest Month; BIO6 = Min. Temperature of Coldest Month; BIO7 = Temperature Annual Range (BIO5-BIO6); BIO8 = Mean Temperature of Wettest Quarter; BIO9 = Mean Temperature of Driest Quarter; BIO10 = Mean Temperature of Warmest Quarter; BIO11 = Mean Temperature of Coldest Quarter; BIO12 = Annual Precipitation; BIO13 = Precipitation of Wettest Month; BIO14 = Precipitation of Driest Month; BIO15 = Precipitation Seasonality (Coefficient of Variation); BIO16 = Precipitation of Wettest Quarter; BIO17 = Precipitation of Driest Quarter; BIO18 = Precipitation of Warmest Quarter; BIO19 = Precipitation of Coldest Quarter. These variables were obtained from the WorldClim portal (Fick and Hijmans 2023), and they derive from monthly precipitation and temperature values, whose purpose is to produce biologically significant information (Fick and Hijmans 2017).

The set of bioclimatic variables was reduced to two main multivariate geographic axes. The underlying objective was to find linear combinations that produced uncorrelated indices in order of importance, capable of describing the variation of environmental data, thus, reducing the multicollinearity of the variables. The generated rasters then served as the main environmental layer to be associated with the observation data to produce a predictive feature by maximum entropy. We estimated the accuracy of our model by probability through a standard accuracy indicator (ROC/AUC). Probable autocorrelative situations, internal to the observation data, were verified and selected locally (LISA) and on a larger scale (MORAN I); we use "spdep" packages for spatial dependence analysis and the "spatialEco" for additional functions in R v. 4.3.1. The average test AUC for the replicate runs was 0.982, and the standard deviation of 0.012. None of the records were dispersed beyond the likely known distribution limits of the species nor did they exhibit discrepant locality predictions.

All climate layers are in 2.5 arc-minute resolution (4.625 × 4.625 = 21.39 km^2/pixel at the equator; GFSC/SIIL) at a resolution considered adequate for the data used.

RESULTS

***Sphaenorhynchus prasinus* Bokermann, 1973**
Figures 1, 2

New records. BRAZIL – Paraíba • Municipality of Santa Rita, Remnant of Atlantic Forest Açude dos Reis, Companhia Usina São João; 07°08′25.05″S, 035°01′07.43″W; 17 m alt; 21.VIII.2023; G.A.P. Filho, F.G.R.

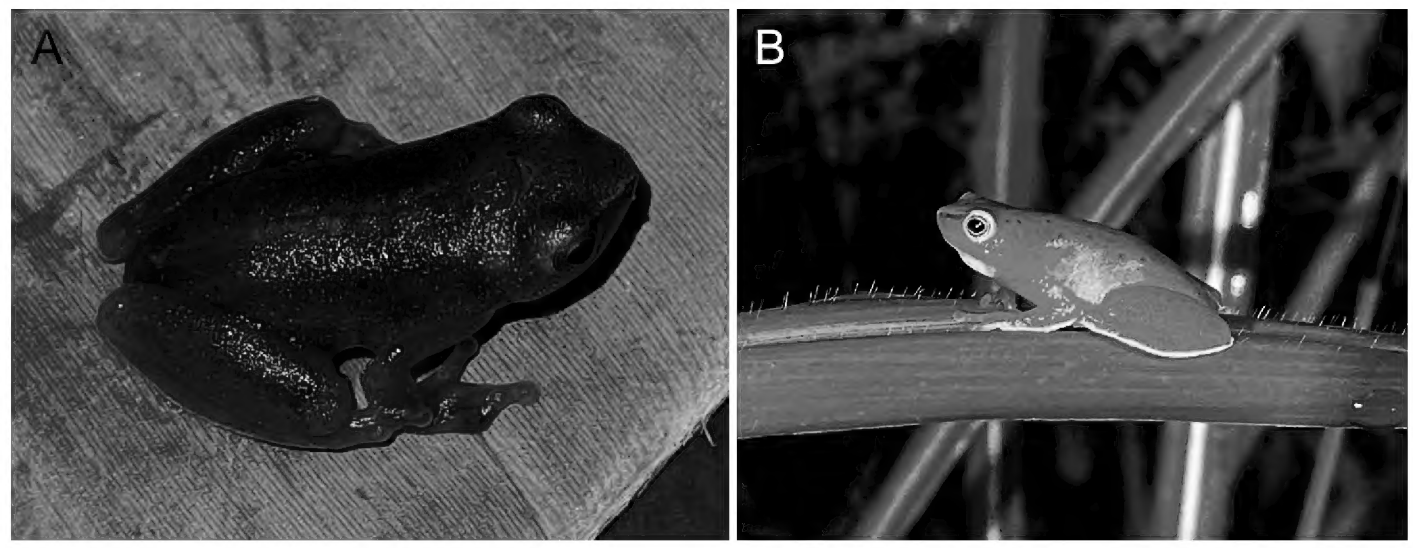

Figure 1. Specimens of *Sphaenorhyncus prasinus* recorded in the Açude de Reis Atlantic Forest remnant in the municipality of Santa Rita, Paraiba, Brazil. **A.** Young individual (CHUFPB29190). **B.** Adult individual (CHUFPB29191) Photos: Gentil A.P. Filho and Frederico G.R. França.

França leg.; specimens on herbaceous vegetation (grasses) at a height of 60–100 cm above ground, near lentic water body; sex indet; CHUFPB 29190. • same locality; 21.VIII.2023; same collectors; same microhabitat; sex indet; CHUFPB 29191.

Identification. The individuals were identified according to the morphological traits described by Bokermann (1973) and Araujo-Vieira et al. (2016). The specimens presented SVL ranging from 15.58 mm (CHUFPB29190) to 25.97 mm (CHUFPB29191) (Figure 1), truncated snout in dorsal and lateral views, presence of a dark canthal line that extends from the tip of the snout to the anterior corner of the eye, indistinct tympanum, absence of a dorsolateral white line from the posterior corner of the eye to the sacral region, well-developed and smooth dermal fold on the ventrolateral surface of the forearms and tarsi, dermal fold on the elbow, rounded calcar appendage and presence of a white dermal fold with rounded lateral margins on the subcloacal region. The coloration of the dorsum and limbs in life were light green, with round, irregular dark-brown spots and a light-green venter. When preserved in alcohol, the specimens presented a yellowish, pale color on the dorsum and limbs, and a whitish venter. The iris was golden, with many brown reticulations. The dermal ornamentation on the ventrolateral margin of the forearms, tarsus, and subcloacal region was white. The chromatic characterization of both living and preserved *Sphaenorhynchus prasinus* specimens was performed based on the standardization suggested by the colors catalogue for field biologists (Köhler 2012).

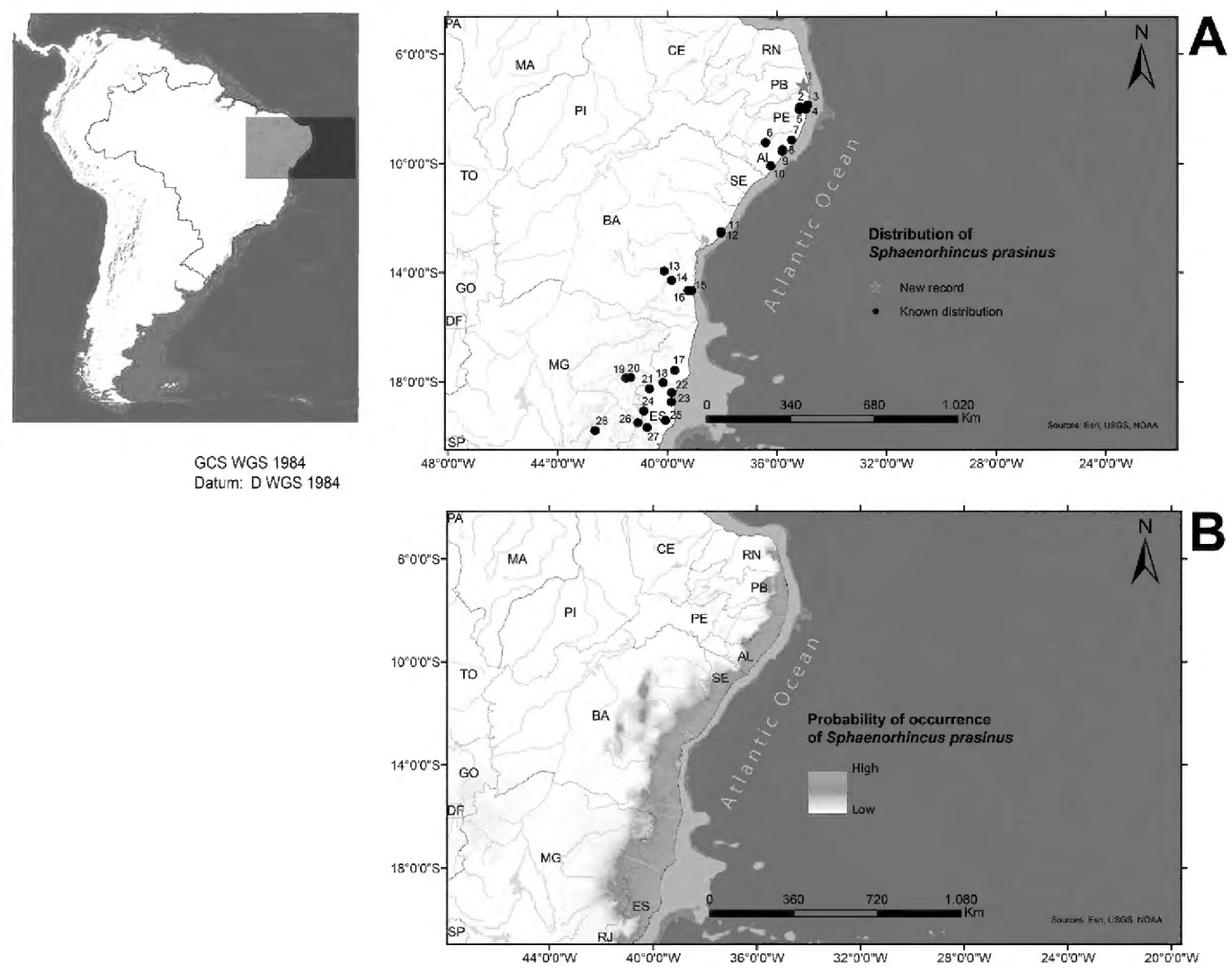

Figure 2. A. Geographic distribution map showing records of *Sphaenorhynchus prasinus* in Brazil. Black circles indicate the previously known locations and red star indicate the new record from municipality of Santa Rita, Paraiba, Northeastern Brazil (this study). **B.** Potential geographic distribution of *S. prasinus* in the Brazilian Atlantic Forest. Warmer colors mean higher environmental suitability value. 1 = Santa Rita; 2 = Paudalho; 3 = Igarassu; 4 e 5 = Recife; 6 = São Lourenço da Mata; 7 = Quebrangulo; 8 e 9 = Maceió; 10 = Coruripe; 11 = Mata de São João (Reserva Sapiranga); 12 = Mata de São João (Reserva Legal Fazenda Camurujipe); 13 = Cariranha; 14 = Itagibá; 15 = Ilhéus; 16 = Uruçuca; 17 = Teixeira de Freitas; 18 = Pedro Canário; 19 = Teófilo Otoni; 20 = Nanuque; 21 = Ecoporanga; 22 = Conceição da Barra; 23 = São Mateus; 24 = Almenara; 25 = Linhares; 26 = Aimorés; 27 = São Roque do Canaã; 28 = Mariléria.

DISCUSSION

The northeastern region of Brazil harbors eight species belonging to the genus *Sphaenorhynchus*, with two of them (*S. cammaeus* and *S. prasinus*) occurring in the Pernambuco Endemism Center (Roberto et al. 2017), the most fragmented and threatened region of the Atlantic Forest (Almeida and Souza 2023). *Sphaenorhynchus cammaeus* is known only from the type locality, Pedra Talhada Biological Reserve, municipality of Quebrangulo, state of Alagoas, while *S. prasinus* is widely distributed in the Atlantic Forest, occurring in the states of Minas Gerais, Espirito Santo, Bahia, Alagoas, and Pernambuco (Pereira et al. 2022; Frost 2024).

Although the study of the amphibian and reptile fauna in the Pernambuco Endemism Center has progressively increased in recent years, there is little information on the community ecology and distribution patterns of most species (Vasconcelos et al. 2014; Vieira et al. 2023; Pereira-Filho et al. 2023). The available data on the natural history of *S. prasinus*, as well as other species of the genus, indicate that these tree frogs inhabit degraded open areas, floodplain forests, forest edges, puddles, and temporary lagoons, where males vocalize while on floating vegetation or partially submerged in water (Araujo-Vieira et al. 2016).

Our record increases the distribution of the species by 944 km from the type locality in the municipality of Ilhéus, state of Bahia and by 80 km from the northernmost record in Igarassu, Pernambuco. The potential geographic distribution suggests that the species is widely distributed in the northern portion of the Atlantic Forest from the Doce river basin to the north of the São Francisco River in the Pernambuco Endemism Center. The new occurrence of *S. prasinu*s in the state of Paraíba represents the northernmost limit of the distribution of the species and highlights the need for more support for research in the region and the intensification of future studies, which could reveal new records, as well as the existence of new species.

ACKNOWLEDGEMENTS

We thank the Compahia Usina São João for its support and dedication in preserving the Brazilian Atlantic Forest. We are in debt to Mr. Severino Dores Alves da Silva for his support and dedication in protecting the Açude de Reis Forest. We are also thankful to the anonymous reviewers and the academic editor, and to Fapesq and the National Council for Scientific and Technological Development (CNPQ) for funding this study (see below).

ADDITIONAL INFORMATION

Conflict of interest

The authors declare that no competing interests exist

Ethical statement

No ethical statement is reported.

Funding

This study was financially supported by Fapesq and the National Council for Scientific and Technological Development (CNPQ) for researching fellowship number 303972/20238. RRNA thanks the CNPQ for productivity research grant number 307011/2022. WLSV thanks the Fapesq (Edital no. 09/2021 Demanda Universal).

Author contributions

Conceptualization: WLSV, GAPF, FGRF, FRD. Data curation: FRD, WLSV, GAPF, RRNA, KSV, FGRF. Formal analysis: WLSV, KSV, FRD, RRNA, PFGPM, GAPF, FGRF. Funding acquisition: WLSV. Investigation: WLSV, GAPF, FRD, FGRF. Methodology: WLSV, KSV, FRD, RRNA, PFGPM, GAPF, FGRF. Supervision: GAPF, FGRF, WLSV, FRD, KSV. Project administration: GAPF, FGRF, WLSV, FRD. Writing – original draft: WLSV, KSV, GAPF. Writing – review and editing: WLSV, KSV, FRD, RRNA, PFGPM, GAPF, FGRF.

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Data availability

All data that support the findings of this study are available in the main text.

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